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Specification and Drawings, as originally filed, with Application for Patent Serial No: **2,419,214**, on February 19, 2003, by **C.M.E. BLASTING & MINING EQUIPMENT LTD.**, assignee of Bjorn Sjolander, Bo Thomas Sjolander and Robert Sjolander, for "Grinding Apparatus for Buttons on Rock Drill Bit".

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ABSTRACT

A grinding apparatus for grinding the hard metal inserts or working tips of drill bits (percussive or rotary), tunnel boring machine cutters (TBM) and raised bore machine cutters (RBM), said grinding apparatus having means to provide relatively high feed/grinding pressure

TITLE: GRINDING APPARATUS FOR BUTTONS ON ROCK DRILL BIT

BACKGROUND OF THE INVENTION

The present invention relates to improvements in apparatus for grinding the hard metal inserts or working tips of drill bits (percussive or rotary), tunnel boring machine cutters (TBM) and raised bore machine cutters (RBM) and more specifically, but not exclusively, for grinding the tungsten carbide cutting teeth or buttons of a drill bit or cutter.

In drilling operations the cutting teeth (buttons) on the drill bits or cutters become flattened (worn) after continued use. Regular maintenance of the drill bit or cutter by regrinding (sharpening) the buttons to restore them to substantially their original profile enhances the bit/cutter life, speeds up drilling and reduces drilling costs. Regrinding should be undertaken when the wear of the buttons is optimally one third to a maximum of one-half the button diameter.

Manufacturers have developed a range of different manual and semi-automatic grinding machines including hand held grinders, single arm and double arm self centering machines for setting up two or more bits to be ground, mobile machines for grinding on the road or in a workshop and grinders designed specifically for mounting on drill rigs, service vehicles or set up in the shop. The present invention is particularly applicable to mobile grinding apparatus of the type described in U.S. Patent No. 5,193,312 and semi-automatic grinding machines as described in U.S. Patent No. 5,070,654 and in International Application published under WO 02/04169.

These types of machines utilize a grinding cup having the desired profile rotated on a spindle or rotor of a grinder at high speed, typically about 12,000 to 20,000 RPM, to grind the carbide button and the face of

the bit/cutter surrounding the base of the button to restore the button to substantially its original profile for effective drilling. In addition to the rotation of the grinding cup, these types of grinding machines include features where the grinder is mounted at an angle to the longitudinal axis of the grinding cup and the grinder is rotated to provide orbital motion with the center of rotation lying in the center of the grinding cup. When grinding buttons, the centering aspects of the grinding machine tend to center the grinding machine over the highest point on the button. On buttons where wear is uneven, typically gauge buttons, this may result in regrinding the button off center from its longitudinal axis.

The conventional grinder designs switch between grinding pressure and balance pressure to achieve the desired effect. This, for example, does not allow for a grinding pressure equal to zero. In conventional grinder designs, the minimum grinding pressure is equivalent to the weight of the arm or lever section and the components attached to it.

Longstanding problems with these types of grinding machines are vibration and noise due to high rotational speeds, wear, the requirement for large compressors for pneumatic systems and relatively long grinding times per button.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide grinding apparatus having means capable of applying relatively high feed forces during grinding, optionally combined with varying or relatively low spindle rpm's.

It is a further object of the present invention to provide high feeds safely, by limiting the

travel of the grinder during grinding in any direction deemed necessary.

It is a further object of the present invention to provide grinding apparatus with means to obtain more power and torque from the grinding head motor.

It is a further object of the present invention to provide grinding apparatus having a relatively compact motor capable of producing substantially higher amounts of torque and/or power than previously used, potentially over a range of rpm's.

It is a further object of the present invention to provide grinding apparatus having a water cooled motor optionally using the same coolant that is used during grinding by the grinding cup.

It is a further object of the present invention to provide grinding apparatus having a frequency inverter to optimize the power and/or torque to size ratio in a grinding machine, and to add the flexibility to change the motor performance characteristics as deemed appropriate for optimized grinder performance.

It is a further object of the present invention to provide biased side load to the grinding machine to help align the grinding machine with the longitudinal axis of the button to be ground.

It is a further object of the present invention to provide a balance pressure to the arm section which controls the movement of the grinding machine along the longitudinal axis of the bit or button when not in use and grinding pressure when in use.

It is a further object of the present invention to provide a controlled combination of balance pressure and grinding pressure to the grinding machine, whenever necessary.

It is a further object of the present invention to provide grinding apparatus having an electronic programmable control panel capable of controlling, monitoring and adjusting all or select operational parameters.

Accordingly the present invention provides a grinding apparatus for grinding the hard metal inserts or working tips of drill bits (percussive or rotary), tunnel boring machine cutters (TBM) and raised bore machine cutters (RBM). The grinding machine is carried by an arm or lever system that permits movement of the grinding machine relative to the bit or button to be ground. This is normally horizontal and vertical movement. Means are provided to provide relatively high feed/grinding pressure. In one embodiment the means to provide relatively high feed/grinding pressure provides a means to limit to limit the travel of the grinding head during grinding.

Another aspect of the present invention relates to means to provide a balance pressure to the arm or lever section that controls the movement of the grinding machine in the direction of the longitudinal axis of the button or bit when not in use and grinding pressure when in use.

Another aspect of the present invention relates to means to provide grinding apparatus having, at higher feed or grinding pressure, lower grinding cup rpm's (0 to 6000 RPM and preferably about 2800 RPM vs 13,500 to 21,000 RPM in conventional grinders) to produce a much more stable and productive environment in which the abrasive (diamond matrix) on the grinding surface of the grinding cup can operate. The result is improved cutting performance and substantially improved cutting point regeneration.

Another aspect of the present invention relates to a grinding apparatus for grinding the hard metal inserts or working tips of drill bits (percussive

or rotary), tunnel boring machine cutters (TBM) and raised bore machine cutters (RBM). The grinding apparatus utilizes a motor capable of producing substantially higher amounts of torque and/or power than previously used, over a range of rpm's, with a relatively compact size and weight. To further optimize the power and/or torque to size ratio, and to add the flexibility to change the motor performance characteristics as deemed appropriate the present invention preferably utilizes a frequency inverter.

A further aspect of the present invention relates to grinding apparatus having a water cooled motor that can optionally use the same coolant that is used during grinding by the grinding cup.

A further aspect of the present invention relates to grinding apparatus having means to monitor, control and adjust all or select operational parameters by an electronic programmable control panel.

Further features of the invention will be described or will become apparent in the course of the following detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the invention may be more clearly understood, the preferred embodiment thereof will now be described in detail by way of example, with reference to the accompanying photographs, in which:

PHOTO 1 is a view from the left side of one embodiment of a grinding apparatus according to the present invention having a grinding machine carried for vertical and horizontal adjustment by an arm or lever system journaled on a stand and with a tiltable table, pivotally mounted in a box, for holding the bit(s) to be ground.

PHOTO 2 is a view of the right side of the grinding apparatus of PHOTO 1.

PHOTO 3 is a close up of the master cylinder of the arm system of PHOTO 1.

PHOTO 4 is a close up of a frequency inverter for the grinding apparatus of PHOTO 1

PHOTO 5 is a close-up of the grinding head for the grinding apparatus of PHOTO 1.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

With reference to the Photos 1 to 5 one embodiment of a grinding apparatus according to the present invention is shown. The grinding apparatus includes means for holding one or more bits to be ground. In this embodiment the means for holding the bit(s) consists of an open box having a table mounted within the box. A grinding machine is carried by an arm or lever system journaled on a stand attached to the rear of box.

In order to minimize operator set up and movement of the bit during regrinding, the table is tiltably mounted within the box at pivot points on each side of the box (see Photos 1 and 2). The table is provided with one or more apertures to hold one or more bits to be ground. When a bit(s) as shown in Photo 1 is positioned in an aperture the bit is held in place by pressure plate controlled by a locking cylinder. A shield is attached to and moves with the pressure plate and fully covers the opening between the rear of pressure plate and back of the aperture. The shield protects the piston rod of the cylinder and prevents accidental pinching of fingers, etc. when the locking cylinder and pressure plate are retracted. The locking cylinder can be depressurized and backed off slightly to rotate the bit (to the next button to be ground) within

the aperture without full retraction of the locking cylinder and pressure plate attached to it.

If the button to be ground is a gauge button, it is typically mounted in the bit at an angle relative to the face of the bit. The grinding machine, in order to properly regrind a worn button, should be aligned with the longitudinal axis of the button. Accordingly to regrind the gauge buttons, in the embodiment shown, the table is tilted to correspond to the angle at which the gauge buttons are mounted in the bit. Alternatively, the grinding apparatus could have, for example, a tilting feature or positioning feature allowing the grinding machine to be aligned with, and provide balance and grinding pressure along, the longitudinal axis of the button, without tilting the bit or button.

The means of tilting the table 4 is best shown with reference to Photos 1 and 2. An arced slot is provided in the left side of the box. A similar slot is provided in the right side of the box so the means for tilting the table can be mounted on either side of the box. A scale is preferably provided above one slot to indicate the angle at which the table will be tilted. A stop (see Photo 1) is positioned within the slot at the desired angle and locked in place by a lever. Once set for a particular bit type, the angle is fixed and doesn't have to be reset for each bit or button to be reground. A cylinder is provided on the left side of the box and the end of the cylinder rod is connected to the side of the table. When activated extension of the rod will tilt the table until further extension is prevented by the stop. As shown in Photo 1, controls for tilting the table and locking the bit(s) in place are provided at the front of the box. One switch controls the cylinder for tilting the table and a second switch controls the locking cylinder and pressure plate. Flow controls are provided to regulate the speed of movement of the table and the pressure plate. The tilting means

can be mounted on either side of the box so that two boxes may be mounted side by side, while leaving the tilting means easily accessible

Large down the hole bits to be reground typically have a relatively long shaft that fits through the aperture(s). In order to regrind smaller bits a floor plate that can be pivoted (slid) in and out of position under the aperture is provided. A knob and slot in the table control the location of the floor plate. Adapters (not shown) for holding multiple small sized bits can be inserted into an aperture. Use of the adapters eliminates repetitive set up time for the operator.

A splash-guard is provided at the front of the box that can be raised and lowered along a slot on each side of the front edge of the box (see Photo 1). A counter balancing spring assists in the ease of operation of splashguard. The splashguard can be set and retained at different heights as desired.

The arm system for carrying and positioning the grinding machine as noted previously is journaled onto a stand at the rear of the box. With reference to the Photos, the arm system consists a first arm section having one end journaled to the stand. The other end of the first arm section is journaled to the backside of a first control box. The first arm section controls the horizontal location of the grinding machine relative to the bit to be reground. To the front side of the first control box is pivotally mounted a second arm section. The second arm section consists of a pair of parallel arms with one end of each arm pivotally mounted to the front side of the first control box. The other end of each arm is pivotally connected to the backside of a second control box. The second arm section controls the vertical movement of the grinding machine up and down.

Within the second control box is a rotation motor and bearing arrangement for providing an orbital

rotation to the grinding machine. The grinding machine is attached to the second control box by means of plates. The grinding machine has an electric motor in the embodiment shown but can also utilize an air or hydraulic motor. Each of the plates is provided with an acruate slot. The angle of attachment of the grinding machine relative to the control box can be adjusted by means of slots and nuts. By having the grinding machine slightly off vertical, nipple formation on the button being reground is minimized and uneven wear on the grinding cup avoided.

A circuit board is provided within the second control box, said circuit board containing the control system for the grinding apparatus including controls and microprocessor to control grinding time on each button, rotational speed of the grinding cup and grinding pressure. In the embodiment shown pressure controls are provided with digital read outs on the front of the second control box to permit the operator to set, or increase or decrease grinding time, rotational speed of the grinding cup and grinding pressure. The microprocessor can be used to provide other functions either manual or automatic. For example, the microprocessor, in the case of an electric motor, can monitor the amperage being used and if it reaches a preset limit automatically decrease the grinding pressure to prevent motor burn out. The microprocessor can also control the flow of coolant to the face of the button during grinding.

Within the first control box (Photo 3), is means to provide a balance pressure to the arm or lever section that controls the movement of the grinding machine in the direction of the longitudinal axis of the button or bit when not in use and grinding pressure when in use. In the embodiment shown, the means to provide a balance pressure to the arm or lever section that controls the vertical movement of the grinding machine

is a cylinder connected to an end of the lower arm of the second arm section.. The end of lower arm extends out from the pivot point at which the lower arm is connected to the first control box. The cylinder provides a balance pressure to the second arm section when the grinding machine is not in use.

The present invention has determined that relatively high feed forces applied during grinding, optionally combined with varying or relatively low spindle rpm's can optimize grinding of the buttons with reduced vibration, noise and grinding time. High feed forces in our self-centering grinders, optionally with biased-sideloads, could potentially cause the grinder to fall of the button with great force (ex. by improper placement by operator). To produce these high feeds safely, a means by which to limit the travel of the feed is required. The need to limit travel may not be limited to feed but in any direction deemed necessary. Examples of means to achieve this would be:

a) separate mechanical locks/brakes that allow only certain amount of travel in the direction of feed or any other axis.

b) integral locks/brakes within one or more of the cylinders used to achieve the balance and/or feed motion. In the embodiment shown one relatively long stroke cylinder with an integral lock/brake is used for the balance and/or positioning movement in combination with a relatively short stroke cylinder providing just the right amount of feed to suffice during grinding. When this type of combination is activated, the travel of the grinder in the direction of feed is limited to the relatively short stroke of the feed cylinder once the grinding cycle is activated. In the event that the grinder falls off the button during a grinding cycle, the chances of any danger to the operator or damage to the grinder etc. is minimized.

c) Other potential solutions to achieve the same objective include motorized screw assemblies to provide controlled movement and/or positioning coupled with suitable load sensors.

All of the above types of solutions could be used in biased sideloads and any other force in any axis deemed necessary.

The grinding pressure can be adjusted.

When grinding buttons the self-centering aspects of the grinding machine tend to center the grinding machine over the highest point on the button. On buttons where wear is uneven, typically gauge buttons, this may result in regrinding the button off center from its vertical axis. One aspect of the present invention provides means to help align the grinding machine with the longitudinal axis of the button to be ground. In the embodiment shown the means to help align the grinding machine with the longitudinal axis of the button consists of, a cylinder having one end connected to the stand and the other end connected to the bottom of the first arm section. The cylinder provides a side load to grinding machine to help align the grinding machine with the longitudinal axis of the button. The side load biases the grinding machine to grind more on either the outside or the inside of the gauge buttons as required thereby tending to shift the grinding machine over the true center of the button. The means to help align the grinding machine with the longitudinal axis of the button to be ground can alternatively include a locking system to lock the arm in place to prevent movement in a direction normal to the longitudinal axis of the button while permitting movement in the axial direction. Suitable side load can also be provided by means other than by the cylinder such as counterweights etc. A further aspect of this invention is to effectively control the grinding cup staying on carbide button delays and variable strength biased side loads

are utilized. This safely enhances the self-centering feature to whatever level deemed necessary. A benefit of a softer enhanced "self-centering" principle, as described above, is that it results in less dramatic wear and loads on built-in grinding cup profile resulting in enhanced grinding cup characteristics throughout it's life.

While typical grinding apparatus are aligned so that the longitudinal axis of the bit is generally vertical during grinding, in the case of very large bits, or in drilling equipment where bits or cutters are mounted in a clustered pattern, grinding may be done with the bit aligned horizontally or some other suitable angle. The present invention is equally applicable to this situation. In this situation the grinding machine may be carried on an arm or lever system and the grinding pressure applied in a horizontal or other suitable direction.

The grinding machine illustrated in Photo 5 utilizes a hex drive system of the type described in U.S. Patent No. 5,639,273 and U.S. Patent No. 5,727,994. In order to make the operation of the apparatus operator friendly, means are provided to easily align and attach the grinding cup and detach the grinding cup after use. A spring-loaded button when depressed will fit into a slot in the rotor and prevent it from rotating. This enables the operator to align the hex drive section of the grinding cup with the drive section of the rotor and then push the grinding cup on. To remove the grinding cup after use the operator presses a lever towards the grinding machine. The lever pivots and the extending arms push the grinding cup away from the drive section of the rotor facilitating removal of the grinding cup from the grinding machine.

Relatively high feed forces in the present invention of between 0 to 100 kilos, optionally with constant and/or variable biased side-loads, requires

more power and torque from the grinding head motor than in known grinding apparatus. The present invention preferably utilizes a motor capable of producing substantially higher amounts of torque and/or power than previously used, over a range of rpm's, with a relatively compact size and weight. To further optimize the power and/or torque to size ratio, and to add the flexibility to change the motor performance characteristics as deemed appropriate the present invention preferably utilizes a frequency inverter. In the embodiment shown in Photo 4, the frequency inverter is installed within the first arm section. A frequency inverter allows for the base frequency (ie. typically 50 or 60 Hz) and voltage to be varied up or down to enable more power and torque to be drawn from a relatively compact motor. The use of frequency inverters allow for substantially changing the motor size to power ratio (ie. Relatively small motors produce more power at higher RPM's). Also, the RPM can be varied by changing the set frequency.

Until the compact solid state frequency inverter (a.k.a. High Frequency Drives), the only way to change the frequency of standard 50 or 60 Hz power supplies was through bulky mechanical means. Motors are designed to produce a certain amount of power and RPM at a given frequency (hence same motor will have different Ram's at 50 and 60 Hz). Changing the frequency allows the present invention to change the RPM's while in many cases maintaining the power. Maintaining power output particularly applies to increasing the motor RPM of many motors above it's rated frequency/RPM.

Using a frequency inverter allows the present invention to utilize a relatively compact motor and pump out the same power at higher RPMs.

At higher feed or grinding pressure, lower grinding cup rpm's (0 to 6000 RPM and preferably about 2800 RPM vs 13,500 to 21,000 RPM in conventional

grinders) has been shown to produce a much more stable and productive environment in which the abrasive (diamond matrix) on the grinding surface of the grinding cup can operate. The result is improved cutting performance and substantially improved cutting point regeneration. In other words the abrasive is able to perform at it's peak performance. In addition, the present invention has determined that variable RPM may be necessary to optimize grinding performance and economy for any given feed and/or carbide button size. Smaller buttons appear to require less feed than larger ones. Smaller buttons may also require somewhat higher RPM than larger ones. Either one or a combination of both variable RPM and feed may also be necessary during grinding of any one button for the purpose of initial heavy material removal rates followed by final surface finishing.

Certain known grinding apparatus using a gearbox principle tying orbital rotation of the grinding machine to spindle or grinding cup rpm do not allow separate controls of orbital rotation speed and grinding head speed. Excessive orbital rotation speed has been shown to be a substantial source of instability during the grinding process. In devices using this gearbox principle, slowing the output spindle down will result in a relatively high orbital rotation speed making it a relatively harsh and unstable process. The present invention optimizes stability and overall optimization of system performance by not tying orbital rotation of the grinding machine to spindle or grinding cup rpm.

Air cooled electric motors are currently used in various button bit and/or cutter grinders. Traditionally air-cooled electric motors with sufficient torque and power for the present invention utilizing high feeds are substantially larger than what is feasible for mounting as a grinding head motor on an articulating arm of any type without making the unit too

cumbersome.

Thermal management of air cooled motors is heavily dependent on the fans capability to force air over the motor, thus cooling it. As the fan speed is lowered, so is it's ability to produce sufficient air flow to sufficiently dissipate heat. In addition, the efficiency of the heat exchange taking place is heavily dependent on the ambient temperature. As the ambient temperature increases, the cooling ability of the air is decreased.

The solution to these problems provided by the present invention has been the development of a water cooled motor that can optionally use the same coolant that is used during grinding by the grinding cup. Since liquid cooling is much more efficient in it's ability to dissipate heat, the temperature of the water is not nearly as critical as the temperature of the ambient air in an air cooled motor. Use of a water cooled motor allows the grinding apparatus of the present invention to grind with a very wide rpm range with no dependency on fans to cool the motor, while drawing substantially higher power and torque. There have been problems reported using air cooled motors (both electric and hydraulic) in hot place (ie. desserts, etc.) due specifically to the high ambient temperatures and the challenges associated with that. Water cooling solves most if not all of these problems.

To control (optionally variably) all of the above functions an electronic programmable control panel capable of issuing the necessary commands can optionally be used. Such a control panel can be used to continuously monitor all or select operational parameters, and if deemed necessary, for example continuously adjust the feed pressure if the motor current (ie. Amps) rises above a set maximum, increase coolant flow if motor temp gets too high, etc. Utilizing software/microprocessor controlled grinding can

influence the grinder behaviour/characteristics. The software can in addition to providing operational parameters also deal with error reporting, service reminders, forced replacement of worn parts/components/modules as deemed necessary for proper operation or to control access for maximized performance. It can also be used to substantially modify grinder behaviour by a simple re-programming or replacement of the microchip/processor. It could be made possible for the operator to update the programming or replacement of chip (and thus the grinders behaviour) right on sight which ensures maximum grinder vailability to the user. This would allow flexibility in terms of future grinder upgradability. For example, a new grinding cup with a new matrix formulation may require the grinder to behave differently. By simply changing the software/programming used by the grinder, the behaviour characteristics and any other key variables can be adjusted as required. This would ensure that user would receive customized/optimized performance from the grinder.

In addition, the control panel software/programming can be configured such that the user could select for example whether long grinding cup life or high material removal rate of the grinding cup is preferred.

The present invention also preferably utilizes a "soft start" where grinding/feed pressure and grinding cup RPM are increased progressively either continuously or in steps to enhances the self-centering feature to whatever level deemed necessary. A benefit of a softer enhanced "self-centering" principle, as described above, is that it results in less dramatic wear and loads on built-in grinding cup profile resulting in enhanced grinding cup characteristics throughout it's life.

Variations of the above described principles of increased feeds/grinding pressure, lower grinding cup RPM, water cooled motor, using frequency inverters, biased side loads, counter balancing and position fixing, that can be used to allow for grinding at angles other than vertical, are within the scope of the present invention. Combinations of variations of the above described principle of increased feeds/grinding pressure, lower grinding cup RPM, water cooled motor, using frequency inverters biased side loads, counter balancing and position fixing can be used to substantially eliminate the need for tilting/pivoting the bit when switching between grinding of face buttons and gauge buttons. Some of the above principles could also be applied to for example pneumatically and/or hydraulically powered motors.

Having illustrated and described a preferred embodiment of the invention and certain possible modifications thereto, it should be apparent to those of ordinary skill in the art that the invention permits of further modification in arrangement and detail.

It will be appreciated that the above description related to the preferred embodiment by way of example only. Many variations on the invention will be obvious to those knowledgeable in the field, and such obvious variations are within the scope of the invention as described and claimed, whether or not expressly described.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A grinding apparatus for grinding the hard metal inserts or working tips (buttons) of drill bits (percussive or rotary), tunnel boring machine cutters (TBM) and raised bore machine cutters (RBM), said grinding apparatus having means to provide relatively high feed/grinding pressure.

2. A grinding apparatus according to claim 1 wherein the means to provide relatively high feed/grinding pressure provides a means to limit to limit the travel of the grinding head during grinding.

3. A grinding apparatus according to claim 1 or 2 wherein lower grinding cup rpm's of from 0 to 6000 RPM and preferably about 2800 RPM are utilized to produce a much more stable and productive environment in which the abrasive (diamond matrix) on the grinding surface of the grinding cup can operate

4. A grinding apparatus according to claim 1, 2 or 3 wherein the grinding apparatus utilizes a motor capable of producing substantially higher amounts of torque and/or power over a range of rpm's, with a relatively compact size and weight.

5. A grinding apparatus according to claim 4 wherein to further optimize the power and/or torque to size ratio, and to add the flexibility to change the motor performance characteristics as deemed appropriate a frequency inverter is provided.

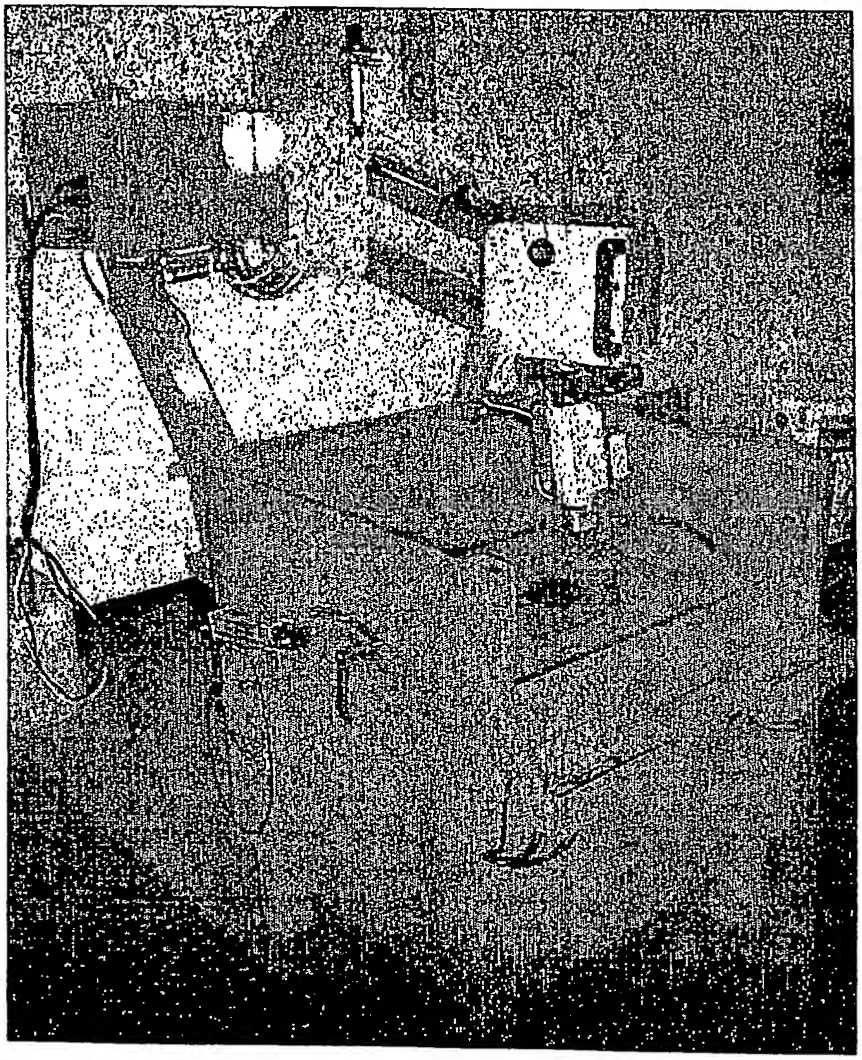

PHOTO 1

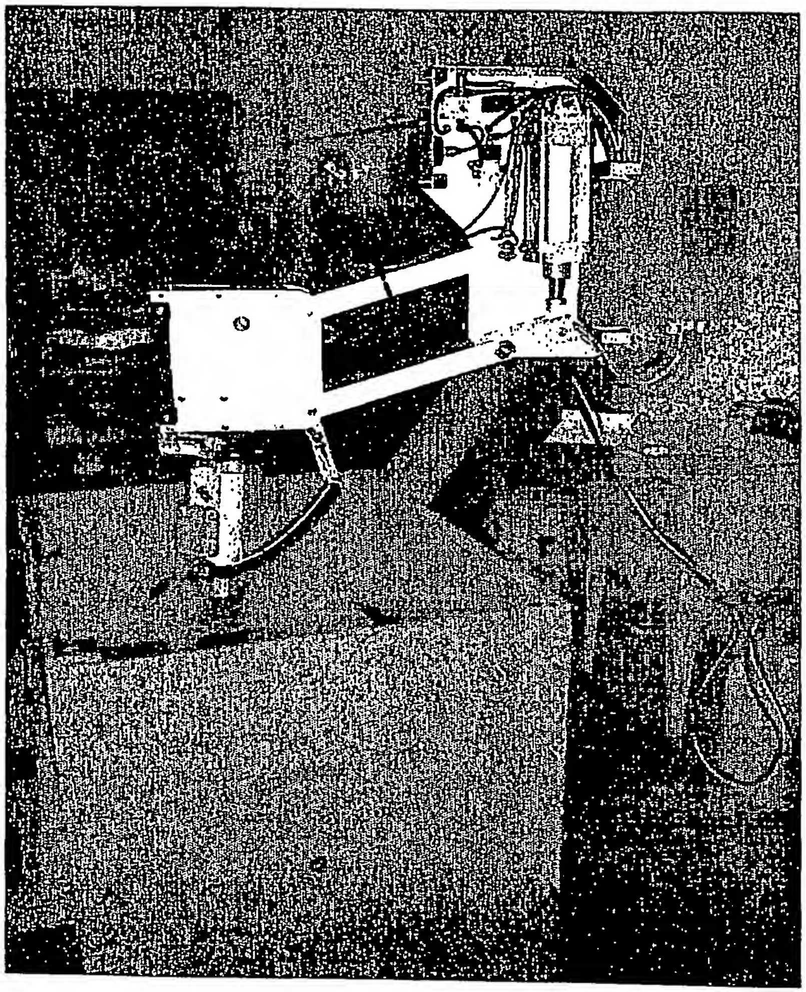

PHOTO 2

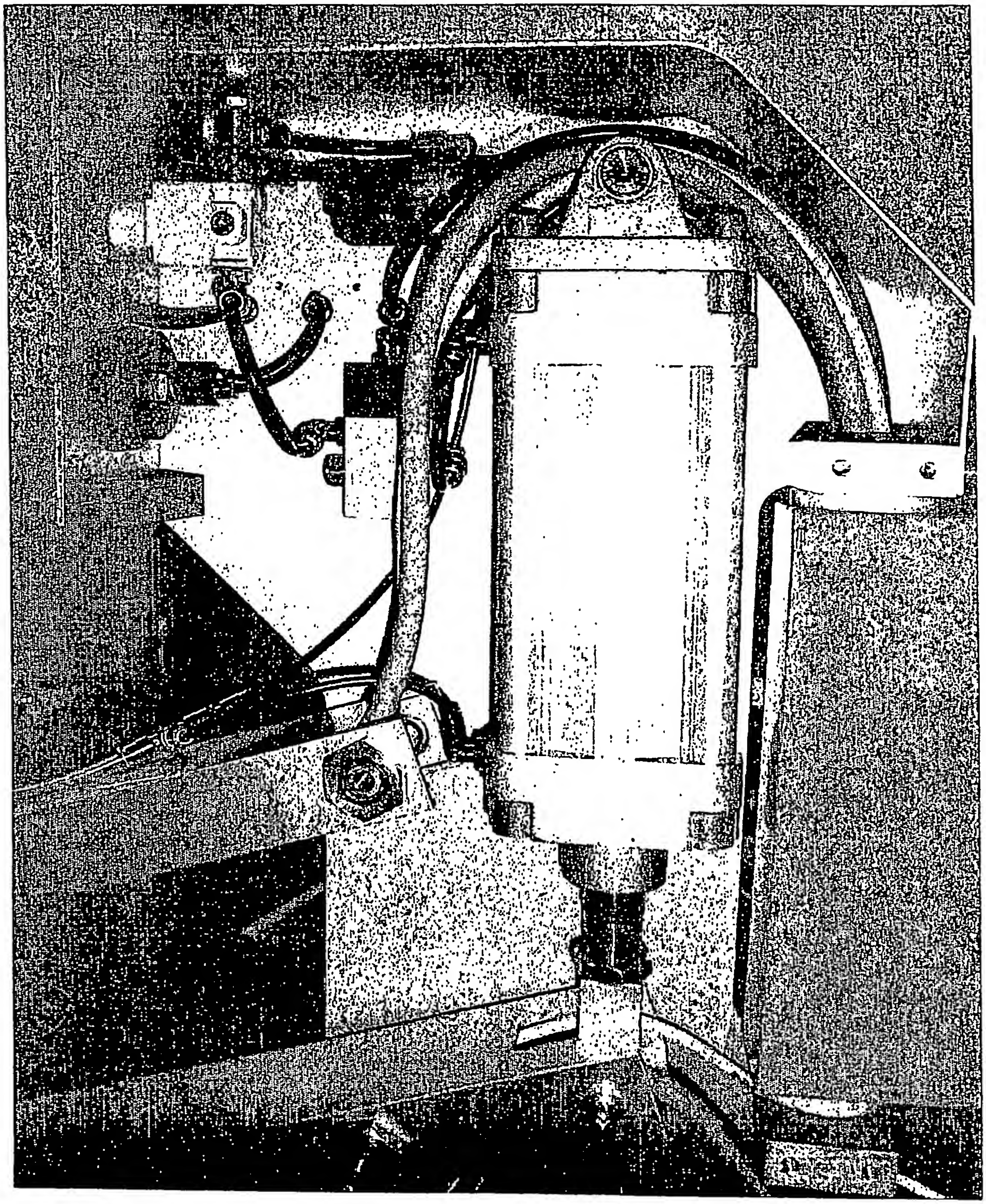

PHOTO 3

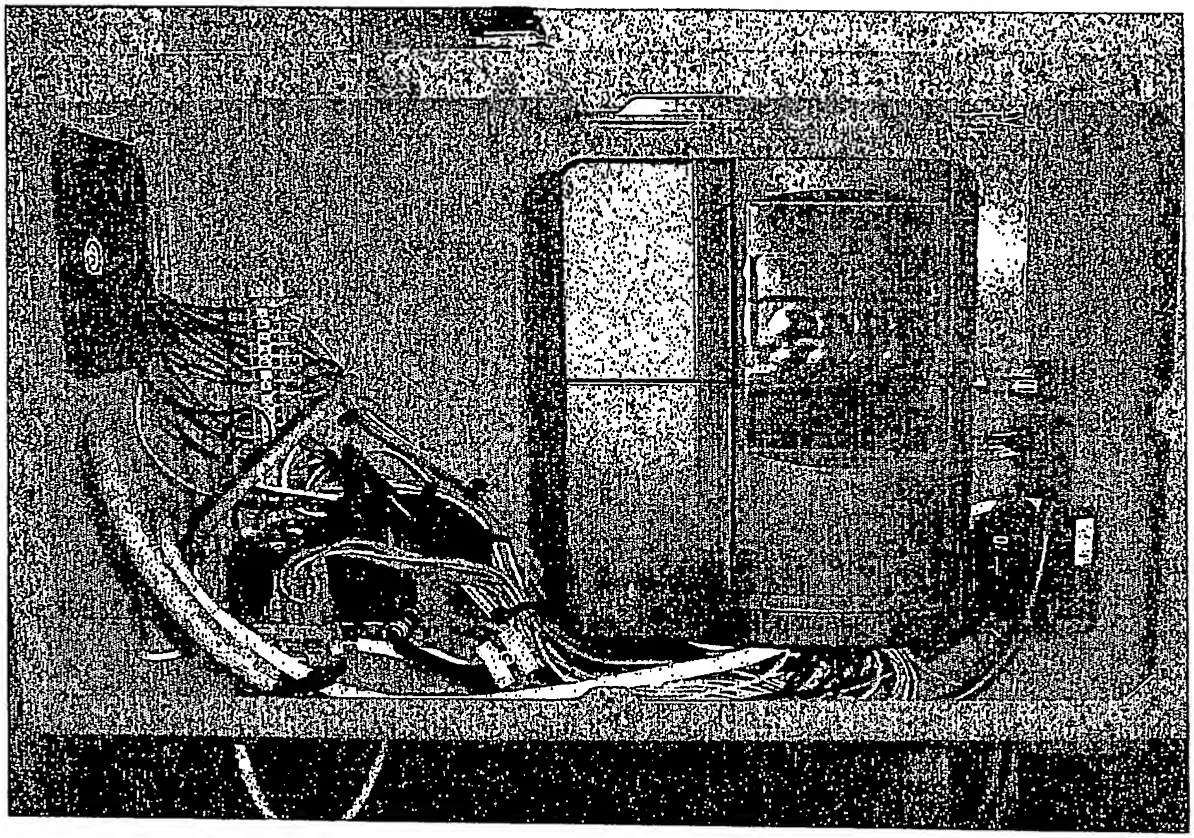

PHOTO 4

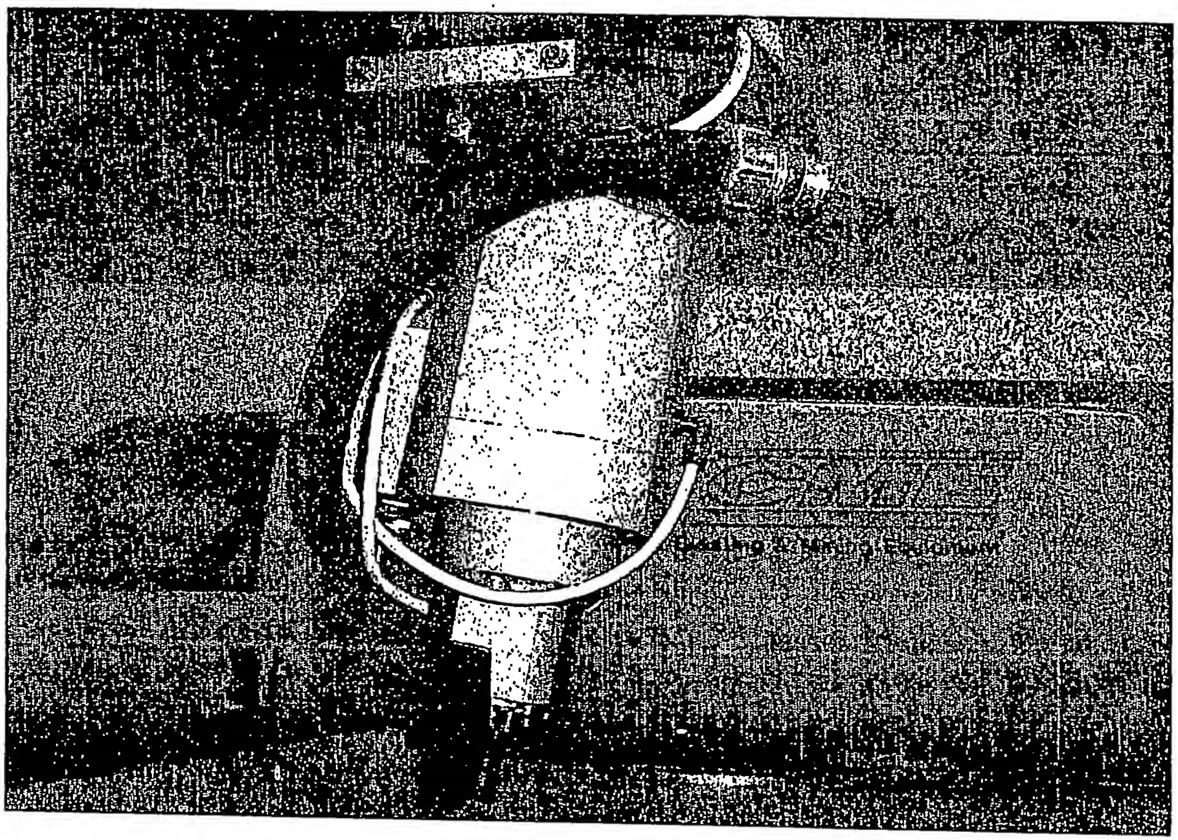

PHOTO 5